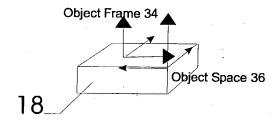
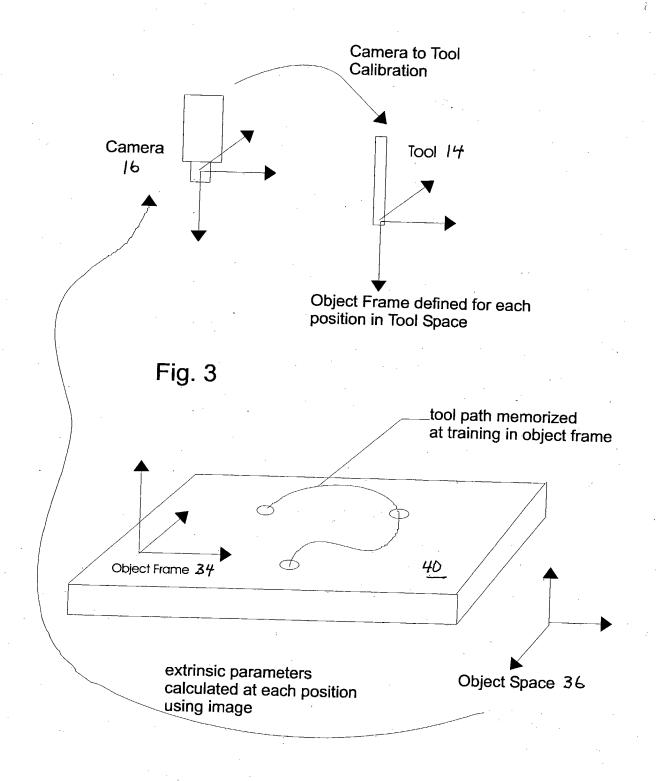
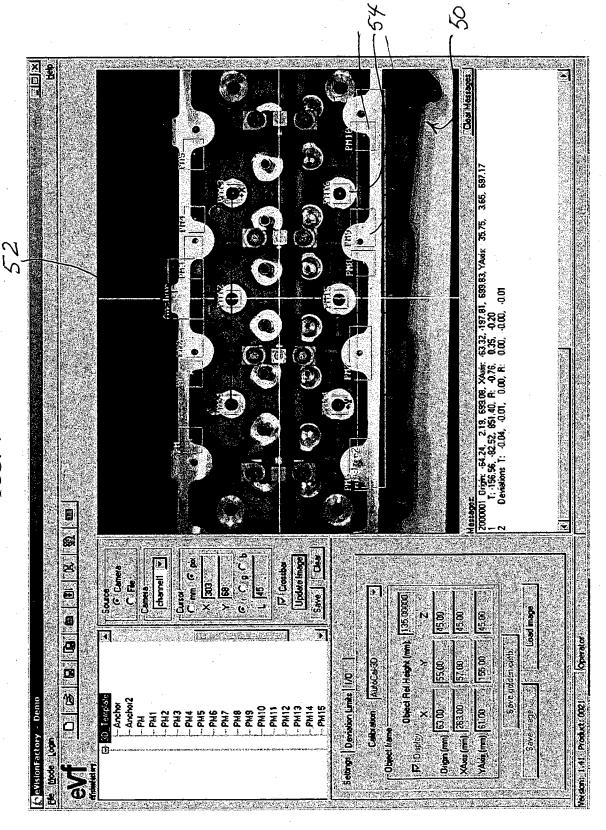


Fig. 2







Calibration of the camera mounted on the robot arm

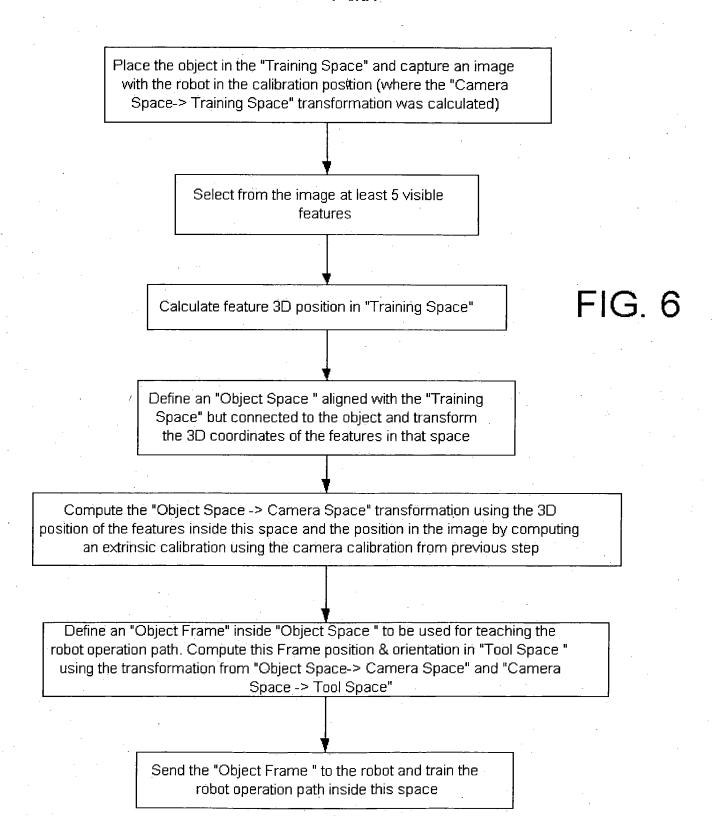
Position the camera on the robot arm so it is orthogonal to the "Calibration Model". Define the "Training Space" for the robot aligned with the template used for calibration

Compute camera intrinsic parameters and the "Camera Space->
Training Space" transformation

Compute "Camera Space -> Tool Space" transformation using the "Camera Space-> Training Space" transformation and inquiring the robot about the "Tool" position in "Training Space"

FIG. 5

Teaching The Object Features & Robot Operation Path



Object Positioning and Robot Guidance

Position the robot in a predefined position above the bin with object. If no object is in the field of view move robot until an anchor feature is found in the image

Use the position and orientation of anchor feature to compute the expected position of the rest of the features; Find the position of all the visible features in the image;

With the positions of features from the image and their corresponding positions in "Object Space" (calculated in the training session) use the camera calibration to compute the transformation between the "Object Space" and "Camera Space". Use camera extrinsic calibration.

Use the transformation from above to calculate the movement of the robot to position the camera so that it appears orthogonal to the object - same position as in training. In this way all the features will be as similar as possible to those at training. This will make the recognition and positioning more accurate.

Find "Object Space -> Camera Space" transformation the same way as in the previous step (using the features positions); Compute object frame memorized at training using the found transformation and "Camera Space-> Tool Space" transformation

Send the computed "Object Frame" to the robot;
Use the "Tool" position to define the frame in "Robot
Space"; Perform the trained operatin path on the object
inside this space

FIG. 7